BEFORE THE STATE OF WASHINGTON
ENERGY FACILITY SITE EVALUATION COUNCIL

IN RE APPLICATION NO. 96-1	)
	)
OLYMPIC PIPE LINE COMPANY:	)
CROSS CASCADE PIPELINE PROJECT	)
	)
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EXHIBIT _____ (CWF-T)

REBUTTAL TESTIMONY OF CONRAD W. FELICE, Ph.D., P.E.

ISSUE:

SPONSOR: OLYMPIC PIPE LINE COMPANY

Q. State your name and business address.

A. Conrad W. Felice, Ph.D., P.E.
AGRA Earth & Environmental
11335 NE 122nd Way, Suite 100
Kirkland, WA 98034-5918

Q. Where are you employed and what is your position?

A. I am the Northwest Regional Manager for the Geotechnical Engineering Group at AGRA Earth & Environmental. Prior to joining AGRA Earth & Environmental in 1998, I was the Northwest Manager for Geotechnical Services at Dames & Moore in Seattle.

Q. Summarize your professional experience.

A. I am a registered professional engineer in seven western states and the province of British Columbia, Canada. My experience includes more than 19 years in technical and management positions on geotechnical engineering and consulting projects where I have been responsible for line management, engineering, innovative research and consulting on a wide variety of projects internationally and in the Pacific Northwest for federal, state, and local governmental agencies and many clients in the private sector. My project experience includes natural hazard assessments, dams, tunnels, water distribution systems, pipelines, heavy industrial structures, and marine structures. I have performed and directed soils investigation, foundation studies, forensic analysis, settlement evaluation, site development criteria, soil compaction studies, slope stability, and landslide analysis, earthquake engineering and seismic risk evaluations for both onshore and offshore facilities. A copy of my resume is attached. CWF-1.

Q. What is your educational background?

A. I have a Ph.D. in Civil Engineering from the University of Utah, an MS in Facilities Management from the Air Force Institute of Technology, and a BS in Civil Engineering from Ohio University.

Q. Have you published in your field?

A. I am the senior author or co-author of over 60 publications and reports.

Q. Are you offering rebuttal for more than one topic?

A. Yes. I am responding to the prefiled testimony related to mass wasting (land slides); earthquake induced liquefaction, the proposed horizontal directional drilled crossing at the Columbia River, and the use of the Snoqualmie Tunnel.

More specifically, I am responding to the testimony of Hank Landau (mass wasting and liquefaction); Susan Shaw (mass wasting); George Wooten (mass wasting); Stephen Bottheim (mass wasting); Deborah Randall (mass wasting); Dee Caputo (mass wasting); Shapiro (mass wasting and liquefaction). I am also responding to the testimony of Kevin Lindsey regarding the particular geotechnical issues related to the Columbia River crossing, and James B. Thompson (Washington State Parks and Recreation) regarding the potential geotechnical issues related to the Snoqualmie Tunnel.

Q. Before you address these specific issues, can you give an overview of how the geotechnical issues were addressed in the Application and how they will be addressed if the Application is approved?

A. The two main objectives of the Application with respect to geotechnical issues were; (1) to describe the impact of natural hazards (e.g., mass wasting, earthquakes etc.) on the pipeline and (2) to assess the impact of the pipeline on the natural environment. If the project is approved, it will then enter into a *design phase*. During the design phase site-specific studies will be conducted and used to develop design criteria to appropriately mitigate identified hazards. Designs will be submitted for approval prior to construction. An example of what will accomplished in a site-specific study has been described in an Action Plan for the Tolt River. This plan has been reviewed and approved by King County. In its final form this Action Plan will be used as a template for other sites requiring a site-specific geotechnical investigation (with modifications to the unique situations at each site). A copy of the most recent draft (March 2, 1999) of the Tolt River Action Plan is attached hereto as Exhibit CSF-2.

Mass Wasting

Q. First of all, what is "mass wasting"?

A. The terms "mass wasting" and "landslide" are commonly used interchangeably in reference to downslope movement of a portion of the land surface under the force of gravity.

Q. Shaw express the concern that during the Application process only sample portions of the pipeline were assessed for mass wasting characteristics. Is that in fact the case?

A. No. The entire pipeline route, and some alternative routes, were investigated for mass wasting characteristics. The purpose of this comprehensive investigation was to address the objectives listed above.

Q. Can you give an overview of how issues relating to mass wasting were addressed in the Application?

A. OPL, following accepted practices for mass wasting hazard identification, located potential hazard areas along the alignment and ranked the level of the hazard as high, medium, or low in order to satisfy the stated objectives. Based on this hazard inventory, OPL identified areas warranting further investigation and provided generally accepted mitigation measures for the hazard level.

Q. How were areas presenting a potential mass wasting hazard identified?

A. A tiered approach was implemented to identify potential hazards. The first tier or phase involved the collection and review of the geologic literature along the alignment that included geologic maps, site-specific reports where available, topographic maps, aerial photographs, and county and local ordinances. An assessment of this information was used to locate potential hazard areas that were plotted on the geographic information system (GIS) base maps that were developed for the project and included as an Appendix to the application. Using this information as a base, a program of reconnaissance was then conducted. The reconnaissance effort included an aerial survey, site visits on the ground and limited sampling at selected locations. Following the reconnaissance phase, the hazard areas and their rankings were refined and the base maps updated accordingly. Based on these results, selected areas were identified as requiring additional investigation prior to design and construction. General mitigation measures were provided for the identified hazard, but the final selection and site-specific design was to be completed using the results of the site-specific investigation. An example of a site-specific investigation program for the Tolt River has been provided as Exhibit CWF-2. The final design will be submitted for approval prior to construction and operation.

Phase I: review of geologic maps, site-specific reports where available, topographic maps, aerial photographs, and county and local ordinances.

Q. Let's start with the first phase. Landau complains that the Application does not identify the scope of the literature review. What literature on geology and site-specific reports was reviewed for OPL's Application?

A. Preparation of the Application involved an extensive literature review. A list of relevant references appears in the Application on pp. 1.5-1 to 1.5-8.

Q. Landau also contends that landowners, land managers or state agencies should have been contacted regarding anecdotal information or unpublished information. Was this done?

A. Some contacts were made but systematic contact of land owners or managers was not made.

Q. What additional literature does OPL intend to review prior the design phase?

A. OPL's intent is to be a thorough as possible. Specific additional documents that will be reviewed include the; initial Tolt Watershed Analysis (Weyerhaeuser Co. 1993) and the five year update, Griffin-Tokul Watershed Analysis, Keechelus Lake Watershed Analysis (Weyerhaeuser Co. 1995); and Mosquito Creek Watershed Analyses (Plum Creek Timber Co. 1997a).

Q. What is your preliminary assessment of these three watershed analyses?

A. The principle purpose of a watershed analysis is to address the cumulative effects of land use practices on natural systems (*e.g.*, fish habitat) and public resources. As part of the watershed analysis, information collected on mass wasting and erosion can contribute to the OPL application. From what has been identified so far (*e.g*., the testimony by Shaw) the watershed results are in general consistent with the data collected during the Application process. However, there does appear to be some useful additional data and this will be incorporated into the investigation and design process.

Q. Let's turn now to the use of topographic maps. How were these used to prepare the Application?

A. The topographic maps were generated from aerial photographs shot for OPL by Triathlon Mapping Corporation who also prepared the digital information which Dames & Moore incorporated into its GIS maps. The aerial photograph scales ranged from about 1:11,000 to 1:14,000 depending on the flight line and topography.

Q. Landau suggests that the use of topographic maps to prepare the Application caused an underestimation of slope failure. Is this a legitimate concern?

A. No, because the maps were not the sole basis in developing the hazard assessment. The applicant relied on an integrated assessment of aerial photographs, existing literature, reconnaissance and site-specific investigations.

Q. Does, as Landau suggests, the absence of information on rock discontinuities in the GTMWH maps indicate that the risk of rock failure incomplete?

A. No. In addition to the maps, the site surveys and aerial reconnaissance. These procedures also indicated no areas having a high or moderate hazard from rockfalls along the alignment that would affect the pipeline.

Q. Landau also contends that the analysis excluded slopes of less than 100 feet; is this accurate.

A. No, the analysis did not explicitly exclude terrain features based on slope length.

Q. How was the information collected in Phase I presented in the Application?

A. An assessment of this information was used to locate potential hazard areas that were plotted on the geographic information system (GIS) base maps that were developed for the project and included as an Appendix B to the Application.

Phase II: program of reconnaissance included an aerial survey, site visits on the ground and limited sampling at selected locations.

Q. How are aerial photographs used to evaluate mass wasting?

A. Aerial photographs are reviewed in stereo to look for evidence of previous mass wasting along the pipeline route. This evidence may include items such as lack of or different vegetation patterns, hummocky topography, escarpments on a slope, or obvious landslide deposits at the base of a slope.

Q. What aerial photographs were used to prepare the Application?

A. The Application was prepared using aerial photographs obtained to prepare the topographic mapping with a scale ranging from 1:11,000 to 1:14,000 for the entire initial route. In addition, other large scale aerial photographs were reviewed for portions of the route and the revised route east of the Cascades, including 1:12,000 from Ellensburg to Kittitas, 1:13,500 to 1:15,000 from east of Kittitas to the Columbia River, 1:11,200 for the realignment around the Corfu landslide area. All of these scales provide a level of detail that exceeds the scale recommend for determination of hazard zones for large areas such as pipeline routes (R. Soeters and C. van Westen at p. 131).

Q. Landau expresses concern about the applicant's reliance on photographs from 1995; could you address this?

A. Given the uniqueness of the alignment of the pipeline route, the applicant emphasized redundancy built into the hazard assessment rather than attempt to locate historic photographs along the unique pipeline route. Specifically, the redundancy was introduced through the integration of multiple resources on which the assessment was derived. In light of this redundancy, the absence of historic photos is not a significant omission.

Q. Landau's testimony states that only 20 of the 41 identified landslide hazards on the proposed route (Table 2.15-4) were evaluated with aerial photographs or site visits. Is that accurate?

A. No. The entire route was evaluated with aerial photographs and a site visit was performed for 40 of the identified landslide hazard (access was not allowed at Swauk Creek). In addition, an aerial reconnaissance was conducted of the entire alignment.

Q. Does the Application discuss local landslide hazard criteria and whether the method used is equal to or better than those described in local code?

A. Critical area ordinance requirements were included as an integral component in assigning the hazard potential rating. Specifically, the applicant used the King County critical area ordinance criteria as a base, because they were determined to be the most restrictive of all of the counties.

Q. What field survey work was done to prepare the Application?

A. Where site-specific field surveys were conducted, the following information was collected and integrated into the hazard assessment: observations of the regional landscape and landforms, surficial geology from available exposures and shallow explorations at several location, vegetation, and hydrologic conditions.

Q. Landau complains that there is no explanation of how information was obtained to evaluate of groundwater conditions. Could you shed light on this?

A. During the field reconnaissance, observations were made of vegetation, obvious areas of wetlands and seepage conditions on slopes. Where available, published information on groundwater levels was used.

Q. How are borings used to evaluate mass wasting?

A. The shallow explorations provided information on the soil characteristics and engineering properties useful to assessing their stability. For example, soil composition and permeability.

Q. Landau questions the soil borings used to prepare the Application. How were the locations selected for drilling soil borings?

A. Nine borings were undertaken as part of the phased hazard assessment. Most areas with obvious deep seated failures were not investigated with borings because the hazard had already been identified and a more extensive investigation will be necessary during the design phase. In addition, shovel and hand auger drillings were performed at 11 other locations where either the principal mass wasting hazard was considered to be shallow or access was not available for truck mounted drilling equipment.

Phase III: classification of areas with potential mass wasting characteristics.

Q. How was the data collected from the review of the literature on geology, topographic maps, aerial photographs, county and local ordinances, aerial reconnaissance, field surveys and borings used to classify the potential hazard for landslides on the pipeline route?

A. First, the data was assessed to determine if there was the potential for a landslide. An inventory was developed of such potential landslide hazards. Second, the data for the potential landslide sites in the inventory were applied to scientific criteria classifying individual hazard levels as "low," "moderate" and "high" impact ratings.

Q. For example, what were the scientific criteria for assigning a high impact rating to a potential landslide site?

A. Slopes in areas with geologic evidence of slope instability, such as slopes in excess of 30% or known areas of inactive slope failures, or having soil/rock types susceptible to failure that will require a site-specific investigation prior to design. In addition, unstable land as evidenced by recent or active slope failure or and generally incapable of accommodating development without increasing stability was given a high impact rating.

Q. Landau raises the questions of whether the designation of a high impact rating occurs when one, all or a combination of the listed conditions are met. Could you explain?

A. The impact rating was determined based on professional judgment considering a combination of the listed conditions.

Q. How many sites are identified in the landslide inventory as having a high or moderate impact rating?

A. 41 sites were identified along the preferred route in the Application.

Q. How will this landslide inventory be used if the project is approved?

A. The inventory will be used to select locations for site-specific investigations.

Q. Landau suggests that the this rating system for classifying landslides is unique to this project. Is that the case?

A. No. "High," "Medium," and "Low" are standard classifications for ranking mass wasting hazards and is generally consistent with standards used by the Department of Natural Resources. The scientific criteria were based on the King County critical area ordinance, which is the most conservative of the ordinances of the counties traversed by the pipeline. In fact, in some cases the criteria used for this project are even more conservative than the King County critical area ordinance. For example, the King County critical area ordinance identifies a steep slope as having a gradient of 40% and the applicant's criteria was 30%.

Q. Landau also questions whether there is any literature discussing this methodology. Can you direct us to the source?

A. The methodology is based on Landslides Investigation and Mitigation issued by the National Research Council (Turner et. al., 1996).

Q. Landau contends that consideration should have been given to using an alternative screening mechanism such as the inventory method, the heuristic analysis, statistical

analysis, deterministic analysis, probabilistic methods and a risk analysis. Can you comment on these alternatives?

A. OPL's decision was to follow the inventory approach. For the purpose of the Application this approach provided a level of assessment with the degree of accuracy to satisfy the stated objectives. As previously described a tiered of phased approach was implement which followed the inventory approach which is referenced text published by the National Research Council (Turner et. al., 1996).

Q. Landau states that the analysis in the Application was restricted to hazards in the half-mile wide study area. Is this in fact the case?

A. No. Potential impact from hazards outside the corridor were also considered. For example, where debris hazards could have impacted the pipeline.

Q. Landau specifically contends that the Application fails to consider the potential for debris flows to trigger landslides at Alice Creek, Hall Creek and Harris Creek. Is this the case?

A. No. They were considered and included in the overall assessment.

Q. What about Landau's contention that the Application overlooked the potential for future land impacts to trigger landslides such as forest fires, earthquakes, development, rising water tables and oil leaks from the pipeline?

A. To the extent possible, these were considered subjectively and integrated into the assessment based on professional judgment.

Q. Landau complaints that the Application ignores the potential for pipeline construction to trigger landslides. Was this issue overlooked?

A. This aspect was integrated by considering the orientation of the pipeline and its construction related to the slope to assess the possibility of trigger landslides.

Q. Landau also points out that the Application does not address the potential for abandonment and decommissioning of the pipeline to trigger landslides. Is this insurmountable?

A. No specific consideration was given for abandonment or decommissioning. However, during the operating life of the pipeline all modifications will require approval prior to implementation. Hence, any changes and their impact will be assessed at that time and appropriate measures implemented.

Phase IV: refinement of hazard areas and their rankings, and identification of mitigation measures.

Q. You explained that Phase III involved the rating of areas using the data collected through the reconnaissance effort which included an aerial survey, site visits on the ground and limited sampling at selected locations. How will these rating be used?

A. Based on these results, selected areas were identified as requiring additional investigation prior to design and construction. In addition, general mitigation measures were provided for the identified hazard.

Q. What are the mitigation measures for the landslide hazards identified in the Application?

A. Table 2.15-5 in the Applications lists general mitigation measures for an identified mass wasting hazard. For example, avoidance, strain gages on the pipe, long-term monitoring, drainage, buttress, increase burial depth, additional exploration for design, reorientation of the pipeline against slope and regrade.

Q. Landau contends that the proposed mitigation measures are inadequate to address the conditions at Peoples Creek, Cherry Creek and the Tolt River. Would you respond?

A. The proposed mitigation measures are stated as being generally accepted for the identified hazard. The locations cited, will require site-specific investigations that will form the basis for the specific mitigation measure to be implemented at each location.

Q. Landau raises the issue of monitoring. What monitoring system will be used once the pipeline is constructed?

A. The appropriate monitoring system will be determined during the site-specific investigation. Based on the results of these investigations, the applicant will consider all the available options to safeguard the environment and the pipeline. The monitoring program likely will consist of at least several of the following components: periodic monitoring of wells to correlate subsurface water levels with stability analysis results; measurements of slope indicator casing to determine whether slide activity is occurring and the depth, direction and magnitude of subsurface ground movements; and regular monitoring of strain gages installed at critical locations on the pipe. Other options include, installation and monitoring of extensometers to detect ground movements and give early warning of landslide activity; visual monitoring of the slide area for evidence of ground movements, such as fresh ground offsets or tension cracks, and installation and monitoring of a ground survey network. Whether the monitoring program will be limited or comprehensive will be based on the assessed risk and compliance with applicable land use and zoning laws. Where possible, automated data acquisition will be implemented.

Liquefaction

Q. What is liquefaction?

A. Liquefaction is a phenomenon primarily associated with the process leading to the loss of strength of loose water saturated sandy soils. The process of liquefaction is mainly but not only associated with earthquakes. During an earthquake, the ground shakes or vibrates. At locations where there is loose saturated sands, the water pressure between the sand grains increases pushing the sand grains apart, thereby decreasing the strength of the soil mass. If the earthquake lasts long enough, the soil will behave as a fluid and will no longer be able support a load such as a foundation resting on the ground surface.

Q. Landau expresses a concern with how the liquefaction assessment is presented in the Application. How were areas along the proposed pipeline corridor evaluated and ranked as to their liquefaction susceptibility?

A. Liquefaction does not occur randomly but is limited to a narrow range of earthquake, geologic, and groundwater conditions. Therefore, the applicant implemented a screening process that classified the liquefaction potential of the geologic materials identified along the alignment according to established liquefaction resistance criteria. For example, liquefaction typically will not occur in clayey or coarse grained sand and gravelly soils or at locations where the depth to groundwater is greater than 40 feet below the ground surface. The screening process accounted for the combination of geology (*i.e.*, soil type), estimated ground acceleration (from the USGS hazard maps), and knowledge of local groundwater conditions. From this screening process, the geologic materials along the alignment were assigned a liquefaction susceptibility rating of 1 through 5, with 5 being the most susceptible to liquefaction (see Table 2.15-2 in the Application). Based on this screening criteria, 27 areas along the alignment were identified as having a high potential for liquefaction where site-specific investigations and or field surveys/reconnaissance were performed.

At sites where borings were conducted or cone penetrometer testing was performed, the Seed and Idriss (1971) procedure was followed to quantify the factor of safety against liquefaction. The Seed and Idriss procedure is the standard industry practice for determining site-specific liquefaction potential. If the computed factor of safety was less than 1.1, the site was considered liquefiable and the possibility for earthquake induced settlement and lateral spreading assessed. The computed factor of safety is site-specific, but for the purpose of the Application, the liquefaction susceptible rating was assigned to the entire area where the susceptible material was located.

Q. Landau points out that maps in Appendix B of the Application do not classify the liquefaction susceptibility as "low," "moderate" or "high," and appears to understate the potential for liquefaction. Could you explain this?

A. Table 2.15-3 accurately summarizes liquefaction susceptibility both by rank and location. As Landau correctly observes, however, there was an error in the process of graphically presenting this data on the maps. Specifically, only the area with "high" susceptibility is shown on the map. The maps can be corrected to include the other liquefaction areas identified in Table 2.15-3.

Q. Landau expresses concern that the DEIS identified two more liquefaction areas than the Application. Could you address these two areas?

A. The first area, Cherry Creek, is in fact addressed as liquefaction area 2 in Table 2.15-3. The Tolt River will be added to the Table. More importantly, site-specific data will be collected at both locations and assessed during the design phase of the project.

Q. Landau purports to identify nine areas of Quaternary alluvium (ranked 5 in liquefaction susceptibility) which he contends are not evaluated in the Application. Were these areas not evaluated?

A. A liquefaction susceptibility rating has been reported in the application for 8 of the 9 areas listed by Landau. The only discrepancy is at stream crossing 147 which will have additional investigations performed during the design phase of the project.

Q. Landau points out the theoretical possibility of *dense* granular soil liquefying during dynamic loading. Does this possibility change the conclusions in the Application?

A. No. Although it is possible for dense saturated granular soil to liquefy, the probability is extremely low. A very narrow set of conditions must be present for this to occur. Following the published USGS hazard maps, an earthquake with a sufficient duration and peak ground acceleration is not predicted that will cause the dense soils to liquefy.

Q. Landau also points out the theoretical possibility of *loose* granular soil liquefying during static loading. Does this possibility change the conclusions in the Application?

A. No. The liquefaction threat to the pipeline is from abrupt and large ground displacements. The loss of soil strength from a combination of high groundwater and static loads will not generate those type of abrupt displacements.

Q. Landau specifically acknowledges that areas with groundwater greater than 12 m below the ground surface are not susceptible to liquefaction. Does the Application properly consider the possibility unidentified shallow water-bearing zones?

A. In past earthquakes were liquefaction has been observed, geotechnical investigations have indicated that the groundwater tables have generally been less than 10 feet below the ground surface. In nearly all the analyses, the depth to groundwater was set at less than 10 feet below the ground, thereby assessing the most likely conditions under which liquefaction would occur.

Q. For the Kittitas Valley to Pasco portion of the proposed pipeline, are the PGA's understated?

A. The PGA's presented were taken directly from the USGS (1996) seismic mapping hazard study. Alternative methods or models that could be used to provide estimates of PGA may yield slightly higher estimates. However, the conclusions regarding what areas have been as having a moderate to high liquefaction potential are unlikely to change significantly.

Q. Why were 15 sites ranked as either 1 (non-liquefiable) or 2 (predominantly non-liquefiable) without a field investigation?

A. A reconnaissance was performed at all the potentially liquefiable sites. In some cases, such as at Cherry Creek, a site-specific investigation will be performed during the design phase of the project. At the remaining locations, professional judgment was used which combined field observations and the screening approach described above to set the liquefaction susceptibility rating. For example, deposits from streams crossing the pipeline route along the I-90 corridor between Snoqualmie Pass and North Bend are too coarse grained to be considered susceptible to liquefaction. At other locations, drainage channels with loose alluvium are too narrow and shallow to contain sufficient soil and shallow groundwater that meet the liquefaction criteria.

Columbia River Crossing: Horizontal Directional Drilling

Q. To which testimony are you responding?

A. I am responding primarily to the testimony of Kevin A. Lindsey.

Q. What is your relevant experience with respect to this subject?

A. I was involved in the site-specific investigations at the Columbia River crossing location, and I was the primary author of the Dames & Moore report (1998) documenting the geotechnical conditions at the site to assess the feasibility of horizontal directional drilling as a crossing method. In addition, I also drafted parts of Olympic Pipeline's Application for Site Certification. I have reviewed the relevant sections of the Draft Environmental Impact Statement, articles available in the open literature, past reports by Dames & Moore, and the Pre-Filed Testimony of Kevin A. Lindsey. I have also discussed the crossing with horizontal directional drilling contractors.

Q. What is your overall reaction to Kevin Lindsey's testimony regarding the Columbia River crossing?

A. A basic premise of Dr. Lindsey's testimony is that the application ignored existing literature and that the geotechnical description of the site was very general. Given that most of the witnesses opposing the pipeline complain of the lack of site-specific information in the application, I find this testimony ironic, as the argument made by Dr. Lindsey is that more regional and general sources of information should have been used in the impact assessment.

The decision to cross the Columbia River by horizontal directional drilling was assessed using the results of a site-specific study that included exploratory borings to physically identify the subsurface soils and geophysical measurements to define the surface profile beneath the river and elevation of the bedrock surface. The results of the study are set forth and summarized in the Dames & Moore report (1998) entitled, "Geotechnical Investigation to Assess Horizontal Directional Drilling at the Columbia River Crossing for the Proposed Cross Cascade Pipeline Project", which is included as an Appendix in the application.

Q. Describe what you did during this geotechnical investigation and how you arrived at your conclusions?

A. The investigation was conducted under the auspices of Dames & Moore at the request of the Olympic Pipeline Company. The purpose of the site-specific investigation was to identify the subsurface soil and rock conditions and geotechnical issues to assess the alternative to cross the Columbia River using the method of horizontal directional drilling. The investigation included an onshore geotechnical investigation, a scour analysis and in-river geophysics. The geotechnical investigation included two borings, one on each side of the river. The scour assessment included a field survey of hydraulic and sediment transport conditions and detailed analyses to estimate the total scour depth. In-river geophysics included bathymetry to profile the hydraulic cross section in the area of the crossing and subbottom profiling to quantify sediment thickness and identify potential obstructions such as boulders. Ground penetrating radar was used to determine the approximate depth to bedrock and quantify the stratigraphy of the river bottom.

Q. Can you summarize the results of that investigation?

A. Based on the ground penetrating radar data, the depth to bedrock was estimated to be approximately 150 feet below the ground surface from the shore area on either side of the river. The soil overlying the bedrock is predominately gravels and this was confirmed through the borings. Potential obstructions of undetermined size were also detected in the subbottom profiling. Total scour depth was estimated to be 24 feet below the bottom of the river. Based on this site-specific data, and discussions with experienced horizontal directional drilling contractors who reviewed the geotechnical data associated with the crossing, horizontal directional drilling was determined to be difficult but feasible. Additional geotechnical borings were recommended to be drilled in the river and onshore in the design phase of the project to reduce the uncertainty in the overburden soil conditions and the top of the bedrock.

Q. Dr. Lindsey claims that the top of the bedrock is actually only six to twenty feet below the base of the river channel, not the 80 to 100 feet listed in the application. How do you respond?

A. A successful horizontal directional drilling operation requires site-specific geotechnical information. Although regional information and nearby project data could be useful, a contractor will not base a bid on such information nor will a reputable contractor comment on whether a crossing will be successful using this information alone. Our information is site-specific, while Dr. Lindsey has constructed a profile from regional and nearby area data and therefore has a high degree of uncertainty in its validity at the crossing location. In fact, geophysical exploration results prior to the construction of the dam show the depth to the top of the bedrock as being highly variable in the area (Dames & Moore, 1956), which reinforces the necessity of depending only on site-specific data for an accurate assessment of conditions at the crossing location.

Q. Dr. Lindsey claims that drilling through bedrock will increase the time and cost of the directional drilling, and he implies that it will also increase the likelihood of drilling mud leaking into the river through cracks in the rock. How do you respond?

A. As noted, based on the current site-specific geotechnical data, the pipeline crossing underneath the Columbia River via horizontal directional drilling will be above the bedrock. Certainly, if Olympic planned on drilling through bedrock, it would increase the cost and time of the project considerably. Drilling through rock is more difficult, and if the additional planned explorations discover bedrock conditions within the drill path, the scope of the investigation will be expanded to assess jointing and fracture patterns to quantify the likelihood of drilling fluids passing through the rock. Drilling through solid rock, however, would and can be done.

Q. Dr. Lindsey suggests that the presence of bedrock so close to the river bottom will force the pipeline to be placed as little as five feet below the bottom of the river, significantly less than the 25 foot minimum described in the application. What is your response?

A. As stated above, if it were the case that the proposed route of the directional drill went through bedrock instead of the sand and gravel substrate observed in the geotechnical investigation, Olympic would likely have to reassess the viability of directional drilling under the Columbia altogether. Olympic would not simply to drill at a shallower depth, as that would represent a risk both to the environment and the pipeline itself.

Q. Dr. Lindsey suggests that Olympic has not adequately considered the potential for boulders in the proposed directional drilling path. How do you respond?

A. The likelihood of encountering potential obstructions was seriously considered as a component of the geotechnical investigation. In fact, the effort extended beyond identifying obstructions to include the likelihood of encountering them at different depths. The results of that analysis are presented in Figure 15 of the Dames & Moore report on the geotechnical assessment. The presence of obstructions can slow down the drilling process, either by necessitating a diversion around them or by drilling through them (*e.g.,* a boulder). While the presence of such obstructions makes the construction process more difficult, the process of reaming the hole prior to pullback of the pipeline significantly reduces the possibility of material dislodging and damaging the pipe. Therefore, the construction process minimizes Dr. Lindsey's concern about obstructions moving and thereby damaging the pipeline. Hence, I disagree with Dr. Lindsey's belief that the likelihood of a boulder collapse and resultant pipeline damage is "pretty high."

Q. Can you address Dr. Lindsey's testimony regarding earthquakes?

A. Dr. Lindsey's testimony regarding earthquakes does not appear to relate to the Columbia River crossing. His concerns are echoed in other testimony, which is addressed in the prefiled rebuttal testimony of Mark Molinari. In any event, I view the likelihood of a pipeline break at the Columbia River crossing as extremely small, as a break would only be possible in the event of very large and abrupt ground displacement, which is unlikely.

Q. How does the application deal with the concern about the ability of drilling muds to migrate into the river through porous flood gravels?

A. I characterize this as more of a construction question than a geotechnical issue. However, to address this concern, Olympic will require the selected drilling contractor to have on staff an experienced mud engineer and will require the use of drilling fluids (*i.e.,* muds) that will minimize infiltration into the soil surrounding the drill hole. However, in general, the chemistry of the drilling fluid is controlled through the addition of bentonite and/or polymers to provide a thin tough liner around the circumference of the drill hole (the liner could be a thin as a dime). The formation of this tough liner or wall cake, is created by deflocculating the bentonite clay particles, sometimes with the addition of polymers, to make the liner impermeable. The impermeable liner aids in minimizing fluid loss (i.e., the separation of water from the drilling fluid) which can lead to a mud loss that could potentially travel through the surrounding soil and into the surface or groundwater system. Also, pressures in the hole will be kept below the overburden soil pressure, which will minimize the likelihood of creating a preferential pathway for the drilling fluid caused by a hydraulic fracture. Additional precautions to prevent fluid loss will be fleshed out in detail at the design stage of the project, after additional studies of the proposed path have been completed.

Q. How do you respond to Dr. Lindsey's concerns about surface water contamination in the Columbia and salmon habitat damage.

A. One of the primary advantages in horizontal directional drilling is that the construction process contemplates no impacts whatsoever to the river itself. The scenarios in Dr. Lindsey's testimony are largely premised on the idea that the pipeline will be constructed at much higher elevations due to the presence of bedrock close to the river bottom. These assumptions are simply invalid, as noted above. Even if Dr. Lindsey were correct in his beliefs about the location of bedrock, however, the crossing plan could be modified to accommodate the bedrock.

Snoqualmie Tunnel

Q. In general, what is OPL's approach to construction of the pipeline through the Snoqualmie Tunnel?

A. OPL intends to use construction methods consistent with those previously used to install exiting utility lines (e.g. AT&T and WorldCom) in the tunnel, to the extent feasible, and alternative methods only if necessary. The methods to be used will be selected so as to have the least potential to impact the structural integrity of the tunnel and the existing subgrade utility lines. Any damage or disturbance to the existing conditions (*i.e.* drainage scuppers, surface coverings, etc.) will be replaced and restored to the original, pre-construction condition. The work will be completed within the time frame and in accordance with the permit or easement conditions established with the land management agencies (*e.g*. Washington State Parks and U.S. Forest Service), including appropriate construction and post-construction monitoring.

Q. How will OPL determine the appropriate construction methods?

A. Prior to final design and permitting, OPL will conduct an evaluation of the structural integrity of the tunnel and further investigate the type and nature of the rock beneath the tunnel. This will include evaluation of vibration levels from the proposed construction equipment relative to typical vibrations generated by trains that traversed the tunnel for approximately 60 years. This information will be used to develop the proposed methodology and prepare a detailed plan for submittal to the regulating agencies, AT&T, and WorldCom for review and comment. Appropriate technical information will be incorporated or appended to the plan to provide the necessary documentation to support the proposed construction plan. OPL and their contractors will also work closely with the AT&T and WorldCom to ensure that their lines are accurately located prior to construction and appropriate measures are employed to prevent damage to their lines. This is standard protocol for subsurface excavation and construction in easements and areas with subsurface utilities.

Q. If the pre-design study indicates a potential for impact to the structural integrity of the tunnel, what additional mitigation measures could be implemented?

A. Mitigation measures that could potentially be implemented if warranted include repairing and/or reinforcing damaged or weak portions of the tunnel liner, placing temporary shoring for support, providing a temporary protective cover to the tunnel liner, etc.

Q. Mr. Thompson also indicated that there may be long-term adverse impacts subsequent to pipeline construction. What are these and do you agree with his assessment?

A. Mr. Thompson indicates there may be a long-term reduction in tunnel integrity after construction, drainage of water that naturally seeps into the tunnel, and restriction of future use of the tunnel for other subgrade utilities. The issues are addressed below.

1. <u>Tunnel Integrity</u>. As previously indicated, the tunnel integrity will be evaluated and appropriate construction and mitigation measures will be implemented to minimize the potential for damage to the tunnel or bedrock behind the tunnel lining. The areas of existing deterioration will be documented. In the event that damage or additional deterioration occurs as a result of construction, this will be detected by monitoring conducted during construction and a post-construction inspection with the appropriate regulatory personnel. Any damaged areas will be repaired. Consequently, future deterioration should not result from the pipeline construction or operation, and OPL should not be responsible for an existing and ongoing natural deterioration process.

2. <u>Drainage Modifications</u>. The pipeline design will incorporate appropriate measures to allow seepage to flow to the existing drainage system consistent with or better than existing conditions. Therefore there should not be long-term impacts to drainage. In addition, drainage scuppers will be used.

3. <u>Restricted Use</u>. The proposed pipeline will not cause any use restriction significantly greater than that already caused by the two (AT&T and WorldCom) lines previously installed. If desirable, provisions for future cables could be made concurrent with pipeline construction.

DATED this 24th day of March, 1999.

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Conrad W. Felice